



## **ANAIS: Status and prospects**

#### Miguel Ángel Oliván on behalf of the ANAIS team

Universidad de Zaragoza Laboratorio Subterráneo de Canfranc

> Roma International Conference on Astroparticle Physics (RICAP) 2014 30 September 2014 - 03 October 2014, Noto, Sicily, Italy

# Outline

- ANAIS Experiment
- ANAIS-25
- Beyond ANAIS-25
  - Status
    - Muon Veto
    - Low energy calibration
    - PMT tests
    - FrontEnd, DAQ & analysis software
  - Prospects

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## **ANAIS Experiment**

250 kg NaI(TI) scintillators to look for Dark Matter (DM) annual modulation at Canfranc Underground Laboratory (LSC)

d LSC, Spain 2450mwe



Confirmation of DAMA/LIBRA positive signal with same target and technique

Experimental requirements:

- Energy threshold < 2 keVee
- Background < 2 c/(keV kg day)

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## ANAIS-25



#### Goals:

- Measure internal contamination <sup>40</sup>K and <sup>238</sup>U and <sup>232</sup>Th chains
- Determine light collection, fine tuning of DAQ, filtering and analysis protocols, general background assessment

Taking data at LSC since December 2012

#### Two modules by Alpha Spectra:

- 12.5 kg, cylindrical
- Quartz windows, no light guides
- Mylar window for low energy calibration
- PMT Ham (R12669SEL2 & R11065SEL)



## ANAIS-25 – Light collection

Detector	PMT model	Phe <sup>-</sup> /keV	
DO	Ham R12669SEL2	16.13 ± 0.66	
D1	Ham R11065SEL	$12.58 \pm 0.13$	

Excellent light collection, better the detector with high quantum efficiency PMTs (R12669SEL2)



Resolution Improvement in all low energy calibration lines

## ANAIS-25 – Threshold



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## ANAIS-25 – Background

Evolution of cosmogenic contributions to background:



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## ANAIS-25 – Background

#### **Bulk Contamination:**



## ANAIS-25 – Background

#### Bulk Contamination:

<sup>40</sup> K	<sup>238</sup> U	<sup>210</sup> Pb	<sup>232</sup> Th
1.25 mBq/kg (41 ppb K)	10 μBq/kg	3.15 mBq/kg	3 μBq/kg

- Radiopurity goals are fulfilled for <sup>40</sup>K (see later) and <sup>232</sup>Th and <sup>238</sup>U chains, but a <sup>210</sup>Pb contamination out-of-equilibrium is present in ANAIS-25 crystals.
- Origin of the <sup>210</sup>Pb contamination identified (crystal growing) and being solved at Alpha Spectra.
- New material by Alpha Spectra could be ready soon to be checked at LSC for radiopurity.

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## ANAIS – Muon veto

The muon flux at Canfranc Underground Laboratory is one order of magnitude greater than at LNGS  $\rightarrow$  muon veto to check systematic effects (16 modules)

The tests at underground have revealed a high rate of events, internal contamination, no muons, that can be discriminated by pulse shape.







# ANAIS – Muon discrimination

#### Muon event discrimination by threshold and shape based on ADC values.



## ANAIS – Low energy calibration system



## ANAIS – PMT Tests

42 Hamamatsu R12669SEL2 units: High quantum efficiency, very low background.

Testing parameters:

- Radiopurity  $\rightarrow$  HPGe
- Relative QE
- Single electron response
- Gain
- Dark Rate



Optical fiber



## ANAIS – PMT Tests

42 Hamamatsu R12669SEL2 units: Developed algorithms to analyze waveforms and extract:

#### Testing parameters:

- Radiopurity  $\rightarrow$  HPGe
- Relative OE
- Single electron response
- Gain
- Dark Rate (< 500 Hz)</li>

Developing quality assurance protocols and selection criteria

Dark Rate (Hz)



# ANAIS – FrontEnd



#### Scalable to N detectors

#### • Trigger:

- Detector trigger → logical AND of two
  PMT discriminators (200 ns window)
- Global trigger → logical OR of all detector triggers
- Measuring:
  - Energy (every PMT, 1 μs integration window, **QDC**) three energy ranges
  - Time delay between signals (TDC)
  - PMT signal waveform (MATACQ)
  - Detector coincidence pattern





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## ANAIS – DAQ Software



# ANAIS – Data analysis software

Robust analysis fully implemented and tested:

- Waveform characterization:
  - Baseline characterization
  - Onset, minimum, DC level area
  - Peak detection algorithm
- Single electron response analysis based on last photoelectron to avoid triggering issues
- Low energy event selection protocols optimized (arXiv:1407.5125)



### **ANAIS** – Prospects

- Simulating next scenarios:
  - More detectors  $\rightarrow$  better <sup>40</sup>K event rejection with coincidence
- Current <sup>40</sup>K contribution in a 250 kg experiment fits requirements: 2 c/keVee/kg/day  $\rightarrow$  acceptable
- Alpha Spectra updated purification protocols -> expected even less <sup>40</sup>K



## ANAIS – Prospects

- Alpha Spectra updated protocols
   → A new module expected soon for
   radiopurity measurements
  - Model for ANAIS-250 considering PMTs, and 40 ppb K bulk contamination.

If <sup>210</sup>Pb reduction not achieved we have also considered two pessimistic scenarios:

- Measured background in ANAIS-25.
- Model for ANAIS-25 considering PMTs, copper encapsulation, optical windows, lead shielding, radon in the inner volume air and NaI bulk contaminations (40ppb K and 3.15 mBq/kg <sup>210</sup>Pb).



### **ANAIS – Prospects**

Projected ANAIS sensitivity to annual modulation supposing:



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### Summary

- Good quality detectors:
  - Light collection
  - Energy resolution
  - Energy threshold
- Electronic FrontEnd, DAQ and Software ready to the full experiment
- PMTs received and being tested
- Muon veto system being characterized
- A new Alpha Spectra crystal, with updated purification and growing protocols, expected soon for check <sup>210</sup> Pb and <sup>40</sup>K contamination
- We are discussing the terms of agreement for 250 Kg NaI(TI)





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## **ANAIS – Slow Control**

- Slow control
  - External Rn
  - Temperatures
    - Environment
    - Frontend
    - Inside the shielding
  - $-N_2$  flux
  - HV Power supply voltage & current

## AS1K – Alpha contamination



1 kg Alpha Spectra grown crystal, encapsulated at UZ to test at LSC for  $\alpha$  contamination .

α rate, determined by PSA. Compatible with broken chain at <sup>210</sup>Pb and contamination at crystal growing.



Alpha Spectra has updated the purification and growing methods → A new crystal available soon to test radiopurity

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